Appendix D

October 1993 Comments and Questions From DemoGraFX to ACATS and The Grand Alliance

Comments From Gary Demos
FCC ATV Interoperability Review Board Member
6 October 1993

My Major Concerns:

Interlace is not interoperable.

59.94 and 60.0 Hz are problematic, when 70+ Hz is required.

I don't believe the assertion that 59.94/60 Hz on 72/75/76 Hz display is acceptable.

We need a reference resolution for creation of N.I.I. content. I suggest 1280 x 720 prog.

Low latency is critical for N.I.I. interactive use. Only the AC leak can provide this.

Other Concerns:

Should an overlay plane definition be part of the ATV system?
Should an open text and graphics language (like SGML) be specified as part of ATV?
Multiscan is an unacceptable requirement for all receivers. Should only be premium units.
Interaction of the transport stream, universal header. encryption, and ATM needs testing

Suggestions:

The G.A. system should be made flexible in aspect ratio for movies (1.33, 1.85, 2.35).

By locking down 1280 and 1920 as horizontal resolutions, a variety of vertical resolutions, using square pixels, can be used to support a variet of aspect ratios.

1440 x 1080 should be replaced with 1280 x 1080 for compatibility with 1280 x 720.
- If non square pixels are going to be used, maintaining 1280 horizontal is preferrable

1920 x 1080 at 24 Hz is apparenly feasible now with the G.A. system.

Use residuals to enhance from 1280 x 720 to 1920 x 1080.
- minimizing 1280 x 720 decoding costs.
- allowing 1280 x 720 displays to receive all ATV pictures.
- ensuring N.I.I. compatible progressive scan capability, compliant with reference.
- residuals can enhance picture further for 40 Mbit/sec cable systems.
- residuals can enhance picture for DVTR release using 50Mbits/second.

A high resolution still image mode (like Photo-CD) should be created and tested.

Conditional replenishment, is association with alpha blending should be part of ATV.

The G.A. should evaluate UniPack as a universal packet header candidate, since its definition is mostly worked out in the context of the the G.A./ MPEG-2 transport

Synchronize nationally to the 8kHz ATM/Sonet clock

Questions From Gary Demos
FCC ATV Interoperability Review Board Member

FCC ATV Interoperability Review, October 6,7 1993

Questions For The Grand Alliance

Computer Screen Text And Graphics Display

1. *How would you propose to handle non-band-limited image data? Such data is typically presented on computer screens as text, window borders, and graphics. Such data is typically raster-aligned and is usually created from a source format such as run-length coding, Adobe Postscript (tm), Apple Macintosh quickdraw (tm), X-Windows (for Unix), or Microsoft Windows (tm) (for PC DOS). Would you use overlay planes in the receiving device? If so, how many bit planes should be specified(2 or 4)? If no overlay planes are specified as part of the system, would you put this image data of text and graphics through your compression algorithm?*

2. *If overlay planes are selected as the preferred mode of sending text and graphics overlays, how would you propose that WP-2 test this capability?*

3. *Are the data areas in your system sufficiently robust, or could they be augmented with further error correction such they might contain graphics screen data as described above (in 1)? Postscript and other screen or printer formatting data types are extremely intolerant to errors. How could errors during screen display be handled if they were to occur? How should WP-2 test the sending of such graphic and text representational formats in the presence of anticipated impairments and errors?*

4. *What mechanism should be used to decide what screen presentation language formats should be supported by advanced television systems? Should the FCC decide using one or more non-proprietary data representations, or should proprietary and non-proprietary display data representations be supported? Example choices might be open standards such as Standard Generalized Markup Language (SGML) using Clear Text (ASCII) encoding (or Binary encoding), or alternatively Open Document Architecture (ODA). A Document Type Descriptor (DTD) for SGML could be easily defined for ATV use. What complexity would be associated with supporting more than one such format for interpretation to everydisplay? What graphics language and syntax should be used to support maps and other graphics?*

5. *Would you expect to see numerous fonts supported in every receiver? What would be the additional receiver display system complexity associated with a large number of fonts vs a few simple fonts? Should the fonts be standardized for every receiver? If so, should WP-2 test the set of fonts selected? Should WP-2 test graphics and text language compliance and functionality?*

6. *Jim Clark, the founder and Chairman of the Board of Silicon Graphics, says that we should plan for 3-D computer graphics in the receiving display. How do you think such 3-D graphics would be integrated with the advanced television picture? How would you expect to support 3-D graphics, and what data formats would you expect to use? Is the data area appropriate and sufficient for this purpose?*

7. *If 3-D graphics were to be used for a backgrounds, and advanced television were to be used for foregrounds, a transparency (or alpha) channel would be required in order to provide anti-aliased matte edges. How would you anticipate sending a partial image together with a transparency channel for such a 3-D and advanced television hybrid moving image? Could there be a mechanism for supporting multiple optional overlays using this technique (e.g. for maps). If such an image compositing capability is feasible with the G.A. system, how should WP-2 go about testing this capability?*

Flexibility Of System

1. *Is the G.A. system somewhat independent of scanning parameters, within limits? What do you estimate the range of such flexibility in scanning parameters might be?*

2. *Should WP-2 test the limits of flexibility of resolution and frame rate for the G.A. system? How should WP-2 go about performing such tests?*

Reference System

1. *Should there be a reference display that could be used to compose text, graphics, and other image material?*

2. *Should the reference display have the resolution of 1280 x 720? Would this be sufficient and suitable as the reference for all National Information Infrastructure (N.I.I.) uses? (Such uses might include education, medicine, collaborative work, library reference, scientific research, etc.)*

3. *If 1280 x 720 is used as the progressive scan and square pixel reference display for composing image material, would not the "1000" line format need to be at least as good in displaying these images as the reference? Would not the "1000" line format therefore need to be progressive scan, since interlace at this resolution would be unacceptably inferior to the 1280 x 720 reference?*

4. *How would WP-2 test compliance with the display quality of the reference used to compose images, text, and graphics for interoperable uses?*

Receivers

1. *What is the concept of the G.A. concerning formats accepted by receivers? Is it anticipated that receivers will all need to be multi-scan-rate? Doesn't this cause a cost burden on every receiver, and preclude providing low cost receivers?*

2. *If 1280 x 720 progressive were to be the "reference system", would it be the intention of the G.A. to support all formats for direct and optimal display on 1280 x 720 single-scan-rate receivers? How could cost be optimized for any format conversions required in order for all G.A. transmitted formats to be optimally presented on 1280 x 720?*

3. *Would data rates and memory sizes be optimal if a 1280 x 720 signal were always present in the ATV signal, such that it could always be decoded directly?*

4. *For presentation of ATV images created using a reference 1280 x 720 system, do you anticipate that 480 line NTSC would have to zoom a factor of 3/2 using progressive scan NTSC (ITV), and a factor of 3 using normal interlaced NTSC, in order to read the text and graphics acceptably?*

Resolution Scalability

1. *Could your system be expanded to include resolution scalability in the compressed format?*

2. *It appears that receiver cost would be optimized at 1280 x 720 if the 1280 x 720 ATV signal were to be decoded directly (without conversion from higher resolution formats). Would this not be optimized if any higher resolution formats, such as 1920 x 1080, were coded as a residual on top of 1280 x 720? Would not the optimal quality and lowest cost be provided for a 1280 x 720-only display if the ATV signal is always present at this resolution, and the residual for 1920 x 1080 (or other higher resolution) could be ignored.*

3. *Will the proposed G.A. system have a higher priority portion of the transmission, like the former ATRC and AT&T/Zenith proposals)? Could a reduced resolution format be decoded from the higher priority?*

4. *The G.A. has indicated that they are interested in being compatible to some degree with MPEG-2 transport and compression. How will this affect the desire by some to use MPEG-2 for multiple NTSC channels in one 6MHz band? Will it be possible to share a 6 MHz band between both MPEG-2 and ATV in the same modulation? What would be the proportional bit rates for such a shared channel? Would 5 Mbits/second be used for MPEG-2 and 15 Mbits/second be used for ATV, with 20 Mbits/second as rate of the 6 MHz modulation (after ECC)? Would it be more efficient to code wide-screen progressive-scan NTSC at 864 x 486 as part of a layered ATV signal, with residuals for 1280 x 720 and 1920 x 1080 resolution enhancements?*

5. *What is your estimate of the cost of a receiver for each year during the next decade for your full advanced television format?*

6. *Zenith has demonstrated 40 Mbits/second over a 6MHz channel on cable. If this doubled data rate were to be allocated for augmentation of the advanced television picture, could your system be expanded to offer higher resolution beyond the first 20 Mbit/sec advanced television format? Should WP-2 test the ability of the G.A. system to offer higher resolution using 40 Mbits/sec? Would the resolution best be enhanced by using a resolution-enhancing residual?*

7. *How important do you think square pixels and progressive scanning may be in creating resolution scalability?*

8. *How could your system be used to send a color still image to a color printer? Could the data area be used in conjunction with the main picture stream to provide this capability? What higher resolution could be achieved? What should WP-2 do to test high resolution still image transport using the G.A. system?*

Temporal Rate

1. *It is my understanding that the proposed G.A. system can provide a 24 frame per second image stream from motion pictures, such that a 72 Hz refresh display could be used. Is this correct?*

2. *Computer displays require a refresh rate which exceeds 70 Hz. How can your system be used or modified to allow presentation of advanced television on computer displays in the home or office? Would there be motion artifacts in such a presentation, and if so, how problematic is their appearance? How would you propose testing this for acceptability in the interoperability testing which will be performed under WP-2?*

3. *If both 59.94 and 60.0 Hz are found to be unworkable for these reasons, could your system be adapted to 72 or 75 Hz? How big of a modification would be required and what would be the expected performance?*

4. *If temporal rate compatibility with computer displays is deemed to be critical, can these temporal rate issues be tested with your system? How much time and effort might such testing take? Can we plan for operating the G.A. system at 72/75 Hz in the WP-2 testing process in order to verify operation at these refresh rates.*

5. *It appears that there is a cost advantage from having the display rate be an integral multiple of the image update rate. For example, if the display rate is 72 Hz, then the image update rates of 72, 36, and 24 images per second are integral multiples (or 75, 37.5, 25). Use of integral rates allows double buffering. Use of non-integral rates, such as 24 frames per second for movies and 60 Hz for display, requires triple buffers to adjust for the non-integral rate relationship. Similarly, artifacts are minimized by integral relationships. Would there be a cost and performance advantage by restricting the ATV rates to 24, 36, and 72, or 25, 37.5 and 75?*

6. *The strong pressure to have ATV operate at 59.94 Hz and 60.0 Hz is coming primarily from those who favor entertainment-only and passive television-only uses. These have primarily been broadcasters, although others have also endorsed these numbers. Since NTSC, which is the source of this rate, is a low resolution medium, why is it being used to set the ATV rate? Isn't motion picture film, which operates at 24 frames per second, the more dominant force in selecting an appropriate ATV frame rate, since film represents our vast resource of existing high resolution materials. Is it proper that the broadcasters and other interests who are pressuring for 59.94 and/or 60.0 Hz carry so much weight that they are precluding an objective consideration of 72 or 75 Hz as the appropriate rate for ATV?*

7. *Zenith demonstrated 40 Mbits/second in a 6MHz band on cable. How best should the extra 20 Mbits/second be used? Zenith demonstrated a pair of 20Mbits/second ATV channels. Would some combination of enhanced resolution and improved temporal rate be another appropriate use of the factor of two increase in data rate available on Cable? Would this best be done by using a temporal rate enhancing residual as well as a resolution enhancing residual?*

Temporal Rate Scalability

1. *Could the use of motion vectors and compressed corrections, which is the G.A. proposal, be used to create a hierarchy of temporal decoding rates? For example, could 24, 36, and 72 Hz image update rates all be decoded directly from the same scalably compressed format? When is it estimated that*

motion vector technology will be useful for temporal rate conversion? Are estimates correct that this is at least ten years away?

2. *Can your system be modified or adapted to update different regions of the image at different temporal rates? If your system already does this in a hidden fashion, is it possible to provide this "conditional replenishment" update capability more explicitly to more fully optimize image presentation?*

3. *Should conditional replenishment or variable screen update capabilities be tested by WP-2?*

4. *Can your system be adapted to provide higher resolution at 24 frames per second than for higher frame rates? In your opinion, would such higher resolution at 24 frames per second provide an enhanced viewing experience of movies over using the same resolution for 24 frame per second material as for the higher rates?*

5. *What should WP-2 be testing with respect to 24 frame per second material? The previous round of testing did not test this directly, but rather only tested 3/2 pulldown embedded in the signal. Should enhanced resolution at 24 frames per second be tested in WP-2?*

Channel Capacity Scalability

1. *During the next ten to twenty years, fiber communication will provide bandwidth to homes and offices in the hundreds or thousands of megabits. The proposed advanced television formats use approximately 20 Mbits/second. How should capacity of hundreds or thousands of megabits be best used? Can your system easily scale to use 40 or 80 Mbits/second? What format parameters would you improve? Examples include wider gamut colorimetry and dynamic range (more bits per pixel), wide screen aspect ratios, higher resolution, more sound channels, higher temporal rate, stereoscopic display, multiple screens, parallel information channels, etc.*

2. *If greatly increased digital capacity were to be available in the future, could you adjust your system to use variable data rate in order to provide more constant image quality?*

3. *What should be tested in WP-2 with regard to the G.A. system's capability for utilizing 40 Mbits/sec or for using variable data rates between 20 and 40 Mbits/second?*

Channel Interoperability

1. *In the G.A. proposal, 188byte packets are used with a 184 byte payload. How would such packet schemes be related to such protocols as ATM which uses 53 byte packets with a 48 byte payload? How would packet priority be used with ATM or other such systems? How would packet dropping or errors be handled?*

2. *What does the G.A. think of the proposal to use one byte in each ATM cell which is divided into 4 bits of sequence number, 3 bits to form a 12 bit checksum with the three other cells, and 1 bit for an ECC code block flag? The sequence number identifies dropped packets, the checksum identifiers errored packets, and the ECC code flag allows low cost decoders to ignore error correction blocks.*

3. *What should be tested in WP-2 with respect to ATM transport of the G.A. data stream?*

Clock Synchronization

1. *A variety of applications will require synchornization of multiple ATV images, including collaborative work, video conferencing, and multiple ATV windows on the screen. How is this best achieved?*

2. *The ATM/Sonet network will have a nation-wide 8kHz reference clock. Would it be a reasonable plan to lock all ATV sources to the nationwide 8kHz clock reference?*

3. *If no synchronization is provided, how much cost and quality degradation do you estimate for the picture and for the audio due to the required resampling?*

4. *Should WP-2 test synchronization of multiple ATV signals in a collaborative work simulation?*

5. *MPEG-2 and CCIR-601/656 have selected a 27 MHz data clock for use with a 13.5 MHz pixel clock. The 27 MHz clock is biased toward non-square pixel formats using 720 pixels in CCIR 601. This is highly problematic for interoperable computer applications which require square pixels and progressive scan. What is the plan for ATV clock rates?*

Data Encryption

1. *It may be desirable to encrypt the advanced television data in order to protect the image and sound from unauthorized viewing. Although the advanced television proposed systems are being tested in the presence of data errors, they are possibly not being tested in an encrypted form. What encryption algorithm for your system's data do you favor? How sensitive is such an algorithm to errors in the data? How would data errors affect the picture quality since the data errors occur in the encrypted data stream? How would networks such as ATM networks with potential packet reordering or dropping affect encrypted data?*

2. *What should be tested in WP-2 with respect to encryption and data errors?*

Latency

1. *Many applications of ATV will require interactive use. The most critical factor in interactive use of ATV will be the end-to-end delay. In the first G.A. presentation, it was indicated that the AC-Leak can achieve an end-to-end delay of 1/10 of a second, whereas the use of I-frames (as in MPEG and MPEG-2) results in an end-to-end delay of 1/2 second. Are these delay times, as presented previously by the G.A., correct?*

2. *Isn't this a crucial issue for ATV system architecture for such applications as video conferencing, collaborative work, interactive server-based games, and navigation of services? If so, isn't the need for the AC Leak a critical requirement?*

3. *Since the use of I-frames, in the style of MPEG-2, is said to cause a 1/2 second end-to-end delay, how much more delay is added by the use of B-frames? Aren't B-frames only useful for coding 24-frame per second movies?*

Interactive Two-Way Communication

1. *Current television delivery via terrestrial broadcast, satellite, and cable is predominantly one-way broadcast. When fiber systems come into existence, two way interactive communication will become feasible. How would you best make use of this two way or interactive communication capability with your advanced television system?*

2. *What is your estimate of the cost of an originating workstation for teleconferencing in your advanced television format over each of the next ten years?*

Storage Media

1. *How would you propose to format advanced television on video tape and video disk type devices? What would be the likely affect of media errors? How might fast forward and fast reverse be implemented?*

2. *Is it feasible to have scalable quality levels for media such as video tape and video disk? Could useful advanced television be presented at 5, 10, 25, 40, 50, or 80 Mbits/second to provide various cost/quality and play length levels? Would a layered residual compression format be optimal for providing this flexibility?*

Compression Efficiency Extensibility

1. *Digital image compression technology, upon which all of the digital HDTV proposals are based, is a rapidly advancing field. Technical developments in just the last two years have seen major new developments and improvements in compression quality and efficiency. This trend is likely to continue for many years. How can your use of data compression take into account rapid major advancements in compression techniques? Can you devise a method to extend your system by upgrading to new more efficient compression while not resulting in immediate obsolescence for those receiving displays using the currently proposed compression technique?*

2. *Do you anticipate that decompression chips in receiving displays will be programmable to some degree? How would you take advantage of such programmability?*

Use Of Header/Descriptor

1. *In the proposed advanced television system, the packet and error protection structure is such that these are placed at the outer most layer. One goal of the header/descriptor is to help identify unknown data streams. For this purpose, it was originally conceived that the header/descriptor would be the outer-most layer. How could your system accommodate the header/descriptor as an outer-most layer? If you intend for the header/descriptor to be an inner layer, how would you propose that it serve its universal identification function for data streams?*

2. *The proposed advanced television system allows acceptable transmission of picture data in the presence of data errors. Audio data and data within the data area may need to be almost error-free. The header/descriptor must also be interpreted without errors in order to function properly. Redundant transmission, error-correction-interleaving, and a separate transport header are possible mechanisms. How might your system expect to support the error-free header interpretation requirement?*

3. *In some of the proposals, data is grouped into packets which are prioritized. In all proposals, the data contains the separate elements of audio, picture brightness, color, motion vectors, data areas, etc. How would you propose to use the header/descriptor to identify each such data sub-area?*

4. *The UniPack universal header proposal to SMPTE from Apple has been developed to work within the MPEG-2 transport layer. The MPEG-2 transport layer is being considered for use by the G.A. Would the UniPack universal packet header proposal therefore be suitable for the header/descriptor needs of the G.A. system?*

Resolution Hierarchy

1. *The format of 1280 x 720 will use a production format of perhaps 1312 x 738 to allow extra border for image processing. A resolution hierarchy for the lower resolution image of 864 x 486 and 648 x 486 would be based upon the scaling fraction 2/3. Most scalable image resolution hierarchies have been based upon 1/2. Do you feel it is feasible to build a scalable resolution compression hierarchy based upon a 2/3 scaling relationship?*

2. *If a 2/3 relationship is created, 1280 x 720 would be stepped up to the next higher resolution of 1920 x 1080. Are there advantages to using this 3/2 relationship over using a 4/3 relationship to 1706 x 960?*

3. *It appears that 1920 x 1080 is desired by some, but difficult to achieve at high frame rates. Some have proposed a compromise to the horizontal resolution down to 1440. The use of 1440 does not appear to interoperate well with 1280 horizontal in the 1280 x 720 format. Would it be appropriate to consider 1280 x 1080 as an alternative to 1440 x 1080? Would 1280 x 1080 result in reduced cost for receivers which operate at both the 720 and 1080 line formats?*

4. *There are many who feel that horizontal resolutions such as 4096, 3072, 2048, 1536, 1024, 1280, and 640 are most desirable for digital display systems due to the match between these resolutions and digital chips and circuits. There is therefore some sentiment that television systems based upon the CCIR 601 horizontal resolution of 720, which include 1408, 1440, and 1920, are not appropriate for many industries. Could your system's use of 1440 or 1408 be adjusted to either of the nearby values of 2048,1536, or 1280? Square pixels would yield 2048 x 1152 and1536 x 864 as well as the familiar 1280 x 720.*

5. *There have been groups considering production formats for the ATV distribution formats of 1920 x 1080 and 1280 x 720. Can you explain the inconsistency between production formats under consideration for 1280 x 720, which provide extra room for processing (perhaps 1312 x 738), and production formats for 1920 x 1080, which do not appear to have any extra room for processing?*

Resolution For Movies

1. *Movies operate at 24 frames per second. Can the highest resolution under present consideration, 1920 x 1080, be supported at this frame rate using the G.A. system?*

2. *Since the largest overall refenue factor in television is the presentation of film material, shouldn't the greatest attention in the selection of ATV be focused on performance and resolution at 24 frames per second? It appears that only sports coverage requires the higher frame rates.*

3. *Using a rate of 24 frames per second, Jae Lim has indicated that his formerly proposed system can convey information at resolutions up to 2560 x 1440. Will the G.A. system retain this capability?*

4. *How much resolution and format aspect ratio flexibility is available for 24 frame per second movie material? Could the G.A. system support 2048 x 870 (2.35:1 aspect ratio), 2048 x 1108 (1.85:1), and/or 2048 x 1536 (1.33 :1)?*

16:9 Aspect Ratio

1. *There have been many who have pointed out problems created by the choice of a 16:9 aspect ratio. These problems include the absence of use in existing film production of this aspect ratio, as well as difficulties in constructing digital display circuits which fall more naturally on factor of two boundaries. Would your system easily accommodate a change to a 2:1 aspect ratio?*

2. *If a 2:1 aspect ratio were alternatively selected for ATV, what resolutions would you favor? Are 1280 x 640, 1440 x 720, 1536 x 768, 1920 x 960, or 2048 x 1024 among the possible choices?*

3. *Would it be desirable to send original material in its original aspect ratio, and require that the receiving device handling the blanking of the border areas? For example, 1.33,1.85, and 2.35 material would be sent at these original aspect ratios. Would it then be possible to have a variety of receiver displays in the market which support a variety of aspect ratios, as chosen by the consumer?*

4. *If multiple aspect ratios in the transmitted /distributed image format were to be used,,would it be better to fix the horizontal values or the vertical values of the material? For example, should 1.33, 1.85, and 2.35 aspect ratios all have a common horizontal resolution (perhaps 1280, 1920, or 2048), or should they have a common vertical value (perhaps 720, or 1024)? Is it correct that digital circuitry is more optimal if the horizontal value is kept constant when supporting multiple aspect ratios?*

Issues With Interlace

1. *How would you present non-band-limited image data on the interlaced display? Would the image presentation be limited to text and graphics in which horizontal features span at least two or four lines? Would this be done by magnifying existing text and graphics by a factor of two?*

2. *Can interlace at 960 or 1080 lines be able to display text and graphics with quality equal to or exceeding a 1280 x 720 reference? Since this appears unlikely, should consideration of an interlaced format be abandoned?*

3. *If you had to revise the interlaced format to have square pixels and be progressively scanned, what format would you favor? Does the G.A. favor 1706 x 960 or 1920 x 1080 as eventually being feasible at high frame rates using progressive scan?*

4. *There are many who feel that horizontal resolutions such as 4096, 3072, 2048, 1536, 1024, 1280, and 640 are most desirable for digital display systems due to the match between these resolutions and digital chips and circuits. There is therefore some sentiment that television systems based upon the CCIR 601 horizontal resolution of 720, which include 1408, 1440, and 1920, are not appropriate for many industries. Could your system's use of 1440 or 1408 be adjusted to either of the nearby values of 2048,1536, or 1280? Square pixels would yield 2048 x 1152 and1536 x 864 as well as the familiar 1280 x 720.*

5. *Why is interlace being considered in the G.A. system? 1280 x 720 is both progressive scan and square pixels at high frame rates suitable for sports. Why is this not completely sufficient for coverage of sports, which is the primary need for high frame rates?*

6. *The desire for high resolution is satisfied at 1920 x 1080 (or other nearby resolution), which appears achievable at 24 frames per second. The desire for rapid frame rate coverage for sports is achieved by using 1280 x 720. What need is there for 1920 x 1080 (or other nearby resolution) using interlace, since the needs and desires of the system appear to be met without the use of an interlaced format?*

Appendix E

DemoGraFX Comments to ACATS and The Grand Alliance Concerning Interlace Misconceptions Following the October 1993 Interoperability Review.

28 October 1993

Subject: Interlace Misconceptions

by: Gary Demos

There appear to be a number of misconceptions concerning the application of interlaced scanning to Advanced Television/High Definition Television (ATV/HDTV), as being proposed for the United States.

Interoperability Considerations Have Been Ignored

The current proposal has apparently be "certified" by the FCC's Advisory Committee on Advanced Televison Systems (ACATS). This certification ignored the majority of the interoperability review board, which strongly opposed the use of interlace. The central theme of the interoperability review board was that interlace is a major barrier to interoperability. As a member of the interoperability review board, I feel that the broad interests of the United States are at stake in the selection of an interoperable ATV/HDTV standard. In particular, the National Information Infrastructure (N.I.I.) will require that ATV/HDTV support computer display of information in addition to television display. The use of interlace is fundamentally incompatible with computer display of information. This results in significant difficulties when attempting to use the ATV/HDTV system for health care, education, library access, collaborative work, and business.

It appears that further refinement to the ATV/HDTV system proposal will be required before it can be useful to the National Information Infrastructure. In its current form, the ATV/HDTV system, as proposed by a "Grand Alliance" of companies, supports two formats at a variety of rates, and one with interlace. The interlaced format has a resolution for computer use equivalent to 540 lines, which is nearly the same as enhanced versions of existing television using a standard known as MPEG-2 in its non-interlaced modes.

Interlace Is The Lowest Quality

Because of the low resolution of the interlaced format for N.I.I. uses, this interlaced format forms a "lowest point" in the quality of the ATV/HDTV proposal. This lowest point, due to the use of interlace, inhibits the use of higher quality because many proposed viewers will only be able to receive images with the quality of this lowest point. Thus, the interlaced format "drags down" the quality of the ATV/HDTV system to the point where the interlaced format becomes the reference for creating images for the N.I.I. The amount of text that can be placed on the screen, the sizes of character fonts of text, the types of drawings and maps, will all be constrained by the interlaced format.

The entire production community for N.I.I. material will be required to produce images which are acceptable to view on the interlaced format. This quality is substantially below the quality of the non-interlaced formats (also known as "progressive scan" formats).

There Is No Migration Path

It has been claimed that the interlaced format forms a "migration path" to a fully progressive format system. However, once a portion of the U.S. population purchases interlaced receivers, they must be served by the common signal for the U.S. This common signal must produce an image which must then be readable on these interlaced receivers. The fact that better receiver quality is available using the progressive formats will not matter, since the amount of text, maps, and other information which can be composed to be readable in the U.S. common signal will only have the low quality required for the interlaced receivers. The U.S. will not be able to gain any benefit from the proposed ATV/HDTV progressive scan formats, since they cannot be used without making images which are unreadable on the portion of the receivers which are interlaced. If these interlaced receivers last in the market for twenty or thirty years, we will not be able to migrate away from them.

False Notion Of Interoperability

The ATV/HDTV Grand Alliance of proposers have said that they have enabled interoperability by making the ATV/HDTV system be interoperable with a variety of formats. By this, they mean that the ATV/HDTV system can accept and transmit a variety of formats. However, they fail to consider that the variety of formats which they propose are incompatible between them. The interlaced format is fundamentally incompatible with the other progressive scan formats.

In addition to the interlaced format being incompatible with the other formats, the ATV/HDTV proposal is also recommending that each receiver be able to receive every format. Their claim is that they offer the choice to every broadcaster and originator of ATV/HDTV to choose the format that they wish to use. This burdens every receiver with receiving the entire range of possible formats which might be chosen. Since some of the formats have substantially higher resolution than others, every receiver must have sufficient memory and processing capability for the highest quality images. However, since images used for the N.I.I. cannot use higher quality than the lowest quality format, which is the interlaced format, the higher quality displays and processing will provide no benefit to the N.I.I. Thus, every receiver must process the highest quality, at the highest cost, while only being able to receive the lowest quality.

Optimized For Entertainment And Against N.I.I. Applications

The higher quality will only benefit entertainment applications where text and maps are not used. However, the entertainment applications do not require the extra quality, since existing television's quality has been used for many years for entertainment purposes. The existing television system already provides sports, news, and entertainment. What it cannot provide is the N.I.I., since a page of text from a book or magazine, or a page of a map, is unreadable on existing television. These crucial N.I.I. capabilities are the main benefit to the U.S. for ATV/HDTV. However, the current ATV/HDTV proposed system is optimized against this N.I.I. key benefit, and optimized for the unneeded entertainment resolution improvement.

False Notion Of Cost Benefits For Interlace

It has been claimed that there are cost benefits to interlace, and this is the reason to allow an interim interlaced format. Irrespective of the fact that the interim interlaced format would be permanent, and not interim, once it is introduced, there is little or no cost benefit to the use of interlace in production, transmission, or in receivers.

False Notion That Interlace Would Allow ATV/HDTV Service Sooner

It has been claimed that by allowing interlace, we would be able to introduce ATV/HDTV service sooner, and that by prohibiting interlace, that it would delay the introduction of ATV/HDTV. Further, it is claimed that the market would be offered lower cost receivers using interlace, and that would stimulate more rapid adoption of ATV/HDTV.

The Interlaced Format Is Poorer In Production & Transmission

These are false notions concerning the benefits of interlace. In production and transmission, the proposed interlaced format requires 12.5% extra processing than the progressive format, and has a corresponding higher data rate burden. The quality of entertainment images will be no better using the interlaced format than using the progressive scan format. Thus, it will result in lower coding efficiency and lower quality, at higher cost, without providing any quality improvement. Further, for N.I.I. and computer-compatible applications, the quality will be greatly degraded due to the presence of the interlace format in the system.

The Interlaced Format Does Not Result In Lower Cost Receivers

The interlaced format does not result in lower cost receivers because the proposed interlaced format will result in a cost which is equivalent or higher than that of progressive scan receivers. The data rate is higher, so the digital processing circuits will cost more. The horizontal resolution is higher, so the display will be more expensive. The horizontal deflection rate is lower at 35kHz compared to 46kHz for the progressive system, but both of these rates must be compared to todays 15kHz rate. The difference in horizontal rate will not make up the difference of the required extra display resolution.

For flat panel displays, and other non-CRT displays, the horizontal deflection rate does not affect the cost, but the other factors do.

If all of these issues are examined, it is seen that the interlaced format will cost more in receivers than the progressive scan formats. Thus, there is no cost benefit to interlace for receivers.

The Proposed Use of 60 Hz Is Not Appropriate For The N.I.I.

It has been found in the computer industry that displays must use display refresh rates in excess of 70 Hz (image frames per second) in order to display text and graphics. The primary benefit to the U.S. of the ATV/HDTV system will be for N.I.I. uses, which fundamentally requires text, maps, detailed images, and graphics. For these uses, it is essential that the ATV/HDTV system operate at rates in excess of 70 Hz. The current ATV/HDTV proposal only operates at the rates of 59.94 and 60.0 Hz. This rate is too low for N.I.I. uses, which require large bright screens and text, maps, and graphics.

If the 12.5% increase in data rate is being proposed for interlace, this increase would be much better applied to the 20% increase required to gain the required image display rates of 72 or 75 Hz.

Conclusion

In conclusion, there are many misconceptions concerning the ostensible benefitis of interlace in the proposed ATV/HDTV system for the United States. Upon considering the issues, however, it is clear that there are no actual benefits from interlace. In fact, the costs appear to be the same or higher in all aspects of the system. Further, there is a severe negative impact from the use of interlace on N.I.I. applications due to the degradation of image quality for text, maps, and graphics.

The choice of an interlaced format in the proposed ATV/HDTV system, and the recent certification of this system, should be immediately reevaluated and reconsidered.

Appendix F

Comments To ACATS in April 1993 Concerning Interoperability Testing

To: Mark Richer
PBS
Chairman
FCC Advanced Television System Subcommittee-Working Party 2

cc: Richard Wiley (PS-WP2), Joseph Flaherty (WP4), Bob Sanderson (WP4), Mark Gaspar (WP6)

Re: Interoperability Testing

13 April 1993

Dear Mark,

As you know, we offered to coordinate interoperability testing once the new testing was announced. During our activities in the last six weeks, we have been able to propose an interoperability testing process. We further have been able to garner broad cross-industry support for interoperability testing by contacting a number of key companies who are willing to contribute technology, time, effort, and possibly funding for interoperability testing.

However, it appears that the current testing process and schedule, under the direction of PS-WP2, does not allow us to accommodate such interoperability testing. Due to the rapid evolution of the ATV process from analog systems to digital, and due to the relatively long development times of ATV systems, we find the ACATS test process is configured inappropriately for digital interoperability testing.

There is not sufficient time or flexibility within the new round of testing to perform interoperability testing.

We therefore face the challenge of how to incorporate such interoperability tests into the ultimate selection and refinement of ATV systems. Advanced Television was originally conceived as an improved entertainment medium. It is now apparent that Digital Advanced Television is much broader in scope than entertainment. Interoperability of ATV systems is essential for digital image communication over the coming National Information Infrastructure of high performance digital networks. Interoperability with computer displays also takes on special significance in light of the convergence of computers and television, and the use of multimedia computers in education, in addition the broad use of computers in production.

In light of this convergence of computers, television, and communications, it will be necessary to perform thorough interoperability tests before any ATV system architecture, including any proposed "Grand Alliance" system, can be embraced with confidence.

It is therefore necessary to consider how to best shedule and perform interoperability testing in light of the apparent inadequacy of the current testing process and schedule.

See the attached section on interoperability testing status for more detail.

Sincerely,

Gary Demos

Mike Liebhold

Interoperability Testing Status

by: Gary Demos

13 April 1993

Testing Materials

According to Peter Fannon at the Advanced Television Testing Center (ATTC), all interoperability testing materials are needed at the ATTC by Friday of this week (17 April 1993). In order to provide such testing materials, it would be necessary to agree on resolutions for such materials, create the materials in these resolutions, gain approval of WP-6, and convert the materials from Exabyte (or other tape media) to HDD-1000. These steps cannot happen within this time being allotted.

It would also be desirable to have higher quality image materials for the progressive scan proponents. One source of higher quality image data would be to scan film at Kodak Cineon or RFX. There has not been sufficient time to select film materials or to perform such scanning.

Without new testing materials, interoperability with a variety of applications for moving images cannot be evaluated.

It would also be desirable to provide 24 frame per second as well as 60 frame per second materials. However, the existing ATV proponent hardware is constrained to use 3-2 pulldown due to the previous testing process. Neither the testing center nor the proponent systems appear to be capable of doing true 24 frame per second tests. It is hoped that 24 frame per second capabilities can be simulated through the existing facility.

It is of some concern that the test materials may not represent the state of the art in image quality in the current round of testing. There appears to be a bias toward live camera images vs film images. Computer Generated Images (CGI) may also be important as a source of future ATV pictures. Use of CGI, film, and live camera images should all be considered fully.

It is of further concern that many other interoperability test images cannot be accommodated within the current process and schedule. Many applications and industries cannot be represented with test imagery under the current testing plan.

It does appear that still images, such as a large map or schematic diagram, could be panned and moved up and down using the Pixar. It is hoped that such a test may reveal some properties of the various proponent systems.

Packetization Testing

In addition to new testing materials, it is also desirable to test packetization for each of the proposed ATV systems. Such tests could evaluate the viability of various header and descriptor mechanisms in the presence of normal errors and packet losses on various transport media. The ability to support a wide variety of data types is central to interoperability.

It would also be desirable to test interoperability of the ATV data stream with various existing and proposed networks including ATM, FDDI, and fast Ethernet. Bellcore, IBM, Hewlett Packard, and others have offered to help with this testing.

Two of the system proponents have VCR implementations. It certainly seems worthwhile to test packetization structures for normal VCR operation (with normal tape errors) as well as for trick modes such as fast forward and fast rewind.

It was our plan to record the compressed bitstream in order to allow the packetization testing to occur subsequent to the testing at the ATTC. However, there has been insufficient time thus far to prepare the instrumentation recorder. WP-2 also has required us to define all of the testing procedures before WP-2 will approve the use of the data recorder. There is insufficient time to prepare the detailed testing plan prior to system tests. It seems to us that the data should be recorded while the systems are in the testing center, even though the subsequent testing procedures cannot yet be fully defined.

The lack of a software simulation of the decoding process for some proponents (at least AT&T/Zenith) would require that processing of the instrumentation data be followed by decoding using proponent hardware.

Thus, it does not appear that any of these packetization and header tests can be performed in the existing process and schedule.

Computer Display Interoperability

In this series of tests, the plan is to evaluate the various systems when their decoded ATV images are displayed on typical computer screens. Since computer screens uniformly have square pixels, and are not interlaced, conversions will be necessary for those ATV systems which are interlaced and non-square pixels. It may be desirable to attempt to use the motion vectors from these systems to de-interlace for such display. However, without an instrumentation recording of the motion vectors, such tests cannot be performed.

Most computer displays use refresh rates above 70 Hz to support the industry trend toward larger and brighter screens. Since the proposed ATV systems operate at 59.94 Hz, a temporal conversion will be necessary. Such a temporal conversion may also find some advantage in the use of motion vectors. However, since there has been no agreement as yet to record the compressed data, such tests may not be possible.

It was claimed by at least one proponent during the WP-4 interoperability review that simple display techniques are sufficient for displaying ATV images on computer displays. Others disputed this assertion. Since interoperability with computer displays affects production as well as a variety of industries and applications, it would seem to be important to test such interoperability.

There may be interactive uses of ATV. The latency and responsiveness characteristics of each proponent system may differ substantially for interactive uses. No procedure for testing interactive use of Advanced Television has yet been devised.

Scalability, & Resolution Conversion

It is likely that ATV receivers will present NTSC programs on the display. It would seem worthwhile to test such NTSC presented at full height (with blank side panels), full width (with discarded top and bottom), and at 1:1 size (small) in the screen center. No material has been prepared for such tests.

Similarly, MPEG-1 decoded images may become popular. The affect of each proponent's coder on decoded MPEG-1 images might be useful to test. MPEG-2 has portions of its coder algorithm in tentative acceptance. MPEG-2 decoded images may also be worth testing.

Similarly, it may be useful to use decoded ATV images as input to MPEG coders to evaluate this relationship of the coders.

In any such concatenated coding tests, it may be desirable to investigate possible coding performance improvement when motion vectors and other coding parameters can be communicated directly between the coders. An instrumentation recording of the compressed bitstream, as well as a software simulation of the proponent ATV system, may be required in order to perform any such tests.

It appears that none of these tests will be possible under the current testing plan and schedule.

The existing proposals do not exhibit much resolution scalability. However, quality can be scaled by one level in some of the systems by decoding a fixed portion of the full data rate. Apparently this reduced quality "usable" image will be evaluated as part of this new round of testing.

Also, it appears that a test of various ancillary data rates has been approved. The systems will be tested for image quality while transmitting 1,2,3, and 4 Mbits/second. The ancillary data will be dummy data, however. Sensitivity to impairments for both the image quality as well as for ancillary data integrity may be a worthwhile test.

ATTC Configuration

One significant hindrance to interoperability testing for these digital ATV systems is the configuration of equipment at the Advanced Television Testing Center. The testing center was initially designed at a time when all of the ATV proposals were still analog. As a result, there are many analog steps in the current testing process. Some of the steps and practices which appear to be questionable in light of digital interoperability testing include

*) The format converters only accept analog RGB inputs for conversion to recording

on the digital HDD 1000. They only provide analog RGB outputs during playback for use as input to the ATV system coders.

*) As a consequence, all of the ATV test systems only provide analog inputs and outputs.

*) There is no mechanism in place to allow moving sequences to be provided via industry-standard tape media (such as 8mm digital tape).

*) Under the current plans, the compressed digital bitstream is not recorded.

*) The Japanese interlaced non-square pixel 1035 line system is used as a "reference".

*) There is no provision for direct evaluation of 24 frame per second film-originated material.

*) The transmitted signal is treated as an RF signal for terrestrial broadcast simulation and for cable testing. No packetized network testing or simulation facilities are available.

Thus the existting testing center is organized in such a way that it does not easily support interoperability testing.

Appendix G

"No" Vote Ballot Comments to SMPTE ATVP Committee 27 April 1994

No Vote Ballot Comments

"1920 x 1080 Scanning and Interface, Third Draft, S17.394"

Gary Demos
27 April 94

attached: re-drafted version of the document which was ballotted

It is not possible to provide comments concerning this document on a paragraph-by-paragraph basis, since I disagree with most of the document. Under the new rules of voting no, new wording is however required which would yield a "yes" vote. I find this a substantial hardship. However, I have re-written the document in a form which would gain my "yes" vote. It is included.

I have not re-written the portion of the document having to do with connectors. I feel that connectors should be optional, since there are a variety of ways to send the data which corresponds to the digital video information, including compressed methods (as is being developed by the Grand Alliance). However, for 8 and 10-bit signals on dedicated single-purpose interfaces, I am sure that the definitions of cables and bit-timing is adequate, assuming that the clocks are adjusted to match the timing in the attached replacement document.

I have attempted to include both 2:1 and 16:9 production aspect ratios. The ASC has recently taken the position that it does not support 16:9 for production, distribution, or display. They are proposing that new advanced television systems be developed using a 2:1 aspect ratio.

I have documented 2048-horizontal-based formats as well as 1920-horizontal-based formats in both aspect ratios.

Rather than 59.94 and 60.0 Hz, which are problematic for film compatibility (3-2 pulldown is disliked) and for computer display compatibility, I have included 72 Hz and 75 Hz. 72 Hz may be best in the U.S. and 75 Hz may work better in Europe and 50 Hz countries. I have also included 36 and 37.5 Hz, which may be useful for production cameras (and computers) during capture (or creation), as would 24 and 25 Hz, but would not be useful for displays.

I specified identical clocks for the 24/36/72 Hz and 25/37.5/75 Hz systems, varying the total number of pixels (and therefore the horizontal retrace blanking interval). However, precise clocks and total pixels and lines are often meaningless in digital image systems. I therefore specified these items as "if required", since the only requirement is that the total time per frame captured be at the exact rate of 24/36/72 or 25/37.75 Hz within the clock tolerance of ±10 ppm.

I have proposed a logarithmic version of R'G'B' and Y', allowing arbitrary dynamic range, but requiring that 250:1 and 1000:1 be supported. Note that 250:1 corresponds approximately to the video curves which were in the balloted document.

I have proposed 8, 10, 12, and 16 bit formats. There is no provision for overshoot in the 8, 10, and 12-bit formats. A 16 bit signed integer format is proposed for use with overshoot and negative number processing requirements. Linear representations of RGB & Y should probably use either the 12 or 16 bit formats. There are no restricted codes, with sync and timing being carried by a universal header mechanism.

The DPX file format header could be used as a header to describe a variety of useful packing modes for 8, 10, 12, and 16 bit data.

I have proposed that Y be true CIE linear luminance, and that Y' be a logarithmic function of Y. I believe that this is not very different from the proposed ballot, but it would require some adjustment of coefficients.

I have proposed that the RGB primaries be specified in a universal header, rather than being pinned down at interim and system values. If none are specified, the system color primaries from the ballot, which correspond to current SMPTE NTSC color primaries, would become the default. I believe that this system would allow expanded gamuts without requiring "step-2-colorimetry" proposals based upon negative RGB values and values above 1.0, as are being discussed.

I also believe that the logarithmic transfer characteristic, having arbitrary dynamic range as a variable, together with 10, 12, and 16-bit representations, would provided arbitrary extensions to dynamic range without needing further future adjustments to the basic system architecture.

The specification of both linear and non-linear representations allows appropriate use of each form, since each form is needed for correct processing. Constant luminance correct filtering characteristics are some of the advantages of defining linear signal representations in addition to the more compact non-linear representations.

I did not specify scan order, since CCD's do not see the picture with the same beam sweep as does a tube camera, both of which differ from a telecine transferring film. The data should come in the order specified, but there should be some flexibility, as is provided in the DPX file format, to allow color sequential as well as color-interleaved pixel and line packings in the data.

I realize that the work of the group has been going in a different and more traditional direction with the current ballot. I strongly applaud the square pixels in the current ballot.

However, I feel that it would be less than optimal to standardize on a production format which is based primarily on 59.94 and 60.0 Hz, and which defines interlaced modes. These are obsolete aspects of television systems which are not really appropriate for an ATV production system for the future. I have also attempted to define the 2:1 aspect ratio production system along side the 16:9 aspect ratio system, so that both aspect ratios can be evaluated more fully.

I am on record as endorsing 2048 and 1024, and other powers of two for the active image area parameters. Numbers such as 1920, 1080, and 960 are clumsy, as is 1152. 1152 is a natural result of the 16:9 aspect ratio, and a power-of-two for the horizontal (2048). Powers of two in horizontal display sizes are most efficient for display system design and use. Using the 2:1 aspect ratio, the format of 2048 x 1024 is possible. The 2048 x 1024 format is especially optimal for digital display systems architectures.

It is my hope that the committee membership will view my effort at reconstructing this document in the spirit in which I intend it, which is as an input to the good work of the committee in attempting to define the most optimal and useful production formats for advanced television development work. It is my expectation that the proposed Grand Alliance system could accept all of the 24 and 25 Hz formats specified, and some of the 36 and 37.5 Hz formats. Reduced resolutions are required at present for 72 and 75 Hz formats.

It is my hope that a family of formats can be constructed which will support reduced resolutions at 72 and 75 Hz. For example, the 1280 x 720 format being proposed by the Grand Alliance is indended for use at 59.94 and 60.0 Hz. I would hope that a set of matching production formats, corresponding to those being defined here, would be created for an intermediate resolution in the region of 1280 x 720. Neither the digital image architecture working group nor the ATVP working group have yet determined the precise relationship of 1920 x 1080 and 1280 x 720 production formats, at any or all of the frame rates being proposed by the Grand Alliance.

It is awkward to define only one production format in a proposed family of Grand Alliance formats, when it has not been demonstrated whether the future 1280 x 720 production format would be compromised by the current ballot parameters. It would therefore be beneficial if all of the production formats were ballotted together which are intended for testing (and possible future deployment) of the Grand Alliance system. If this document is re-ballotted, I would hope that the next ballot would not only include comments and changes from my proposed changes, but also a structure for how the 1280 x 720 format may be accommodated as a production format with this system. I would like to see a 1280 x 640 format, or some format near these parameters in the 2:1 aspect ratio, also be defined for testing. Such a format could likely accommodate 72 and 75 Hz progressive scan.

Proposed SMPTE Standard

Advanced Television Formats – 2048 x 1152 & 1920 x 1080 (16 : 9 aspect ratio) 2048 x 1024 & 1920 x 960 (2 : 1 aspect ratio)

Contents

1 Scope

1.1 This standard defines image formats at 2048 x 1152 & 1920 x 1080 using an aspect ratio of 16:9, and at 2048 x 1024 and 1920 x 960, having an aspect ratio of 2:1, as given in table 1. Frame rates of 24, 25, 36, 37.5, 72, and 75 Hz are specified.

This standard also specifies color encodings.

Cable and connector interfaces are not specified in this standard.

2 Normative references

(to be completed)

Table 1- Scanning systems

System nomenclature	Samples per active line (S/AL)	Lines per picture height (L/PH)	Frame rate (Hz)	Samples per total line (S/TL) (if required)	Total lines per frame (if required)	Sampling frequency fs (MHz) (if required)
2048x1152/24/1:1	2048	1152	24	2400	1250	72.0
2048x1152/25/1:1	2048	1152	25	2304	1250	72.0
2048x1152/36/1:1	2048	1152	36	2400	1250	108.0
2048x1152/37.5/1:1	2048	1152	37.5	2304	1250	108.0
2048x1152/72/1:1	2048	1152	72	2400	1250	216.0
2048x1152/75/1:1	2048	1152	75	2304	1250	216.0
2048x1024/24/1:1	2048	1024	24	2400	1100	63.36
2048x1024/25/1:1	2048	1024	25	2304	1100	63.36
2048x1024/36/1:1	2048	1024	36	2400	1100	95.04
2048x1024/37.5/1:1	2048	1024	37.5	2304	1100	95.04
2048x1024/72/1:1	2048	1024	72	2400	1100	190.08
2048x1024/75/1:1	2048	1024	75	2304	1100	190.08
1920x1080/24/1:1	1920	1080	24	2200	1125	59.4
1920x1080/25/1:1	1920	1080	25	2112	1125	59.4
1920x1080/36/1:1	1920	1080	36	2200	1125	89.1
1920x1080/37.5/1:1	1920	1080	37.5	2112	1125	89.1
1920x1080/72/1:1	1920	1080	72	2200	1125	178.2
1920x1080/75/1:1	1920	1080	75	2112	1125	178.2
1920x960/24/1:1	1920	960	24	2200	1000	52.8
1920x960/25/1:1	1920	960	25	2112	1000	52.8

1920x960/36/1:1	1920	960	36	2200	1000	79.2
1920x960/37.5/1:1	1920	960	37.5	2112	1000	79.2
1920x960/72/1:1	1920	960	72	2200	1000	158.4
1920x960/75/1:1	1920	960	75	2112	1000	158.4

3 General

3.1 A system which is compliant with this specification shall utilize a universal header/descriptor mechanism to specify:

– Which scanning parameters from Table 1. are being used

– Phosphor primaries, if RGB, R'G'B', Y, Cr, Cb, or Y', Cr', Cb' systems are used, and which such format is used.

– Whether the data is in 8, 10, 12, or 16 bit format, and the packing of such data

3.2 For R'G'B' and Y',Cr',Cb' representations, dynamic ranges of 250 and 1000 shall be supported. Other ranges may be supported as well.

4 Scanning

4.1 If scanning requires a reference clock in order to support horizontal and vertical retrace time intervals, the clocks from Table 1 shall be used. Such clocks, if used, shall be maintained to a tolerance of ± 10 ppm.

4.2 If alternate clock timing is used for pixels and/or lines, the frame times of 24.0 and 72.0 shall be maintained to an tolerance of ± 10 ppm.

5 System colorimetry

5.1 Y is the linear representation of luminance and shall correspond to CIE Y.

5.2 Y' shall be defined as follows:

$Y' = 1+\mathrm{Log}_{10}(Y)/\mathrm{Log}_{10}(D)$, $1/D<Y<1.0$,
Y set to 1/D if $Y<1/D$

where D is the dynamic range of the system, expressed as the ratio of the maximum to minimum useful signal levels. For example, a 1000:1 dynamic range would use D=1000

5.3 R,G, and B will be defined as linear representations, with the primary points specified in CIE x,y coordinates to 3-decimal digits of precision using the universal header. If these x,y chromaticity coordinates are not specified, the system is not compliant with this specification. In such a case, however, the following default chromaticities will be assumed:

	CIE x	CIE y
Red	0.640	0.330
Green	0.300	0.600

Blue	0.150	0.060

5.4 R'G'B' are defined as follows:

$R' = 1+\mathrm{Log}_{10}(R)/\mathrm{Log}_{10}(D)$, $1/D<R<1.0$,
R set to 1/D if $R<1/D$

$G' = 1+\mathrm{Log}_{10}(G)/\mathrm{Log}_{10}(D)$, $1/D<G<1.0$,
G set to 1/D if $G<1/D$

$B' = 1+\mathrm{Log}_{10}(B)/\mathrm{Log}_{10}(D)$, $1/D<B<1.0$,
B set to 1/D if $B<1/D$

where D is the dynamic range of the system, expressed as the ratio of the maximum to minimum useful signal levels. For example, a 1000:1 dynamic range would use D=1000

5.5 When using RGB and R'G'B' representations, the white point will be specified in CIE x,y coordinates to 3-decimal digits of precision using the universal header.

5.6 If no white point is specified, a white point will be implied by equal R, G, and B or R', G', and B' values using the average of the CID x,y coordinates specified in the header for each primary.

5.7 Cr and Cb are defined as follows:

$Cr = R - Y$
$Cb = B - Y$

Where the chromaticities of the R, and B primaries are specified using a universal header

5.8 R, G, and B are determined from Y, Cr, and Cb as follows:

$R = Y + Cr$
$B = Y + Cb$

G will be determined according to the chromaticities of R, G, and B, utilizing Cr, Cb, and Y.

6 Raster Structure

6.1 The universal header structure shall be utilized to convey blanking, synchronization, and timing information. No reserved codes are utilized.

6.2 The clean aperture of the picture for each format is as follows:

Format	Clean Aperture	Border
2048 x 1152	2016 x 1134	32 x 18
2048 x 1024	2016 x 1008	32 x 16
1920 x 1080	1888 x 1062	32 x 18

1920 x 960   1888 x 944   32 x 16

6.3 The sample aspect ratio is 1:1 ("square pixels").

6.4 The center of the picture shall be located at the center of the clean aperture (and of the production aperture), midway between the lines and pixels adjacent to that center.

7 Digital Representation

7.1 Digital R, G, B, R', G', B', and Y' components shall be computed as follows:

L_d=(D-1)L + 0.5; D=2^n

where:

L is the component value in abstract terms from zero to unity

n takes the value 8, 10, or 12, corresponding to the number of bits to be represented.

and L_d is the resulting digital code value.

A signal value of 0 results in a code value of 0, and a signal value of 1.0 results in a code value of 255, 1023, or 4095, corresponding to 8, 10, and 12 bits respectively.

7.2 When overshoots in the signal must be preserved, a 16-bit signed representation is utilized. Digital R, G, B, R', G', B', and Y' components shall be computed as follows:

L_d=(D-1)L + 0.5; D=2^{n-2}

where:

L is the component value in abstract terms from zero to unity.

n takes the value of 16. n-2 corresponds to the number of significant bits to be represented without overshoot.

and L_d is the resulting digital code value.

The high order bit is the sign bit, and the next highest order bit is used to represent values in the range of 1.0 to 2.0.

A signal value of 0 results in a code value of 0, and a signal value of 1.0 results in a code value of 16383. A signal value of 2.0 results in a code value of 32766. A signal value of -1.0 results in a code value of -16383.

7.3 Digital Cr, Cb, Cr', and Cb' components shall be computed as follows: